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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : C09C 1/36		A1	(11) International Publication Number: WO 97/24406 (43) International Publication Date: 10 July 1997 (10.07.97)
(21) International Application Number: PCT/US96/20606			(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM).
(22) International Filing Date: 24 December 1996 (24.12.96)			
(30) Priority Data: 08/582,207	2 January 1996 (02.01.96)	US	Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
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(54) Title: A NOVEL WAY TO SYNTHESIZE STRUCTURED COMPOSITE PREMIUM PIGMENTS**(57) Abstract**

A structured composite pigment composed of TiO₂, calcined clay and polyaluminum chloride (PAC). A novel process is disclosed for producing an aggregated composite premium pigment having superior optical, physical and dispersion characteristics for papermaking applications. The aggregated pigment is produced by chemically aggregating a mixture containing TiO₂ and calcined clay with polyaluminum chloride of a basicity of 10-85 % in alkaline conditions of pH 8.5-10.5.

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A NOVEL WAY TO SYNTHESIZE STRUCTURED COMPOSITE PREMIUM PIGMENTS

BACKGROUND OF THE INVENTION

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A strong market demand for titanium dioxide is continuously increasing globally. The projected demand to cater the global need is expected to grow 4 percent in 1995 and 3 to 4 percent per year through the end of this decade. Despite announced plans by the majors producers for increasing the production of titanium 10 dioxide, the supply will remain snug due to limitations in the operating capacity. Due to increasing demand and limited resources, price hikes could be sought by producers in an effort to recover from general inflation and to justify adding new TiO_2 capacity.

In order to balance the ever increasing demand and the price hikes of TiO_2 , new technologies have emerged to substitute composite pigments of clay and titanium 15 dioxide (also called titanium extenders) for the TiO_2 . The major objective of making such composite pigments is primarily to reduce the consumption of TiO_2 and, hence the cost, without significantly sacrificing the performance in the end application.

In designing and synthesizing the composite premium pigments several physical aspects need to be considered such as the optical properties, particle size 20 distribution, average particle size, shape, dispersion characteristics of the constituting pigments and the ability to handle the end product. Of these parameters, optical properties are the primary concern. According to Fresnel equation of reflectivity, the reflectivity F when there is an obstacle in the path way of a ray of light traveling in medium 1 of refractive index n_1 due to medium 2 of refractive index n_2 , can be given 25 as:

$$F = \frac{(n_1 - n_2)^2}{(n_1 + n_2)^2}. \quad [1]$$

According to Eq. [1], an increase in F , which is a crude indication of increase in the light scattering or opacifying power, may be achieved by increasing the differences 30 between the refractive indices of medium 1 and 2. In other words, the constituting pigment materials for the composite pigment should differ in their refractive indices by a large value.

The second most elementary aspect of the composite pigment design is the particle size of the premium pigment with a high refractive index. According to the

Mie theory (Mie, G., Phys. Lpz., vol 25, pp. 377, 1908), one can calculate the average particle diameter for a single spherical TiO_2 (rutile) particle of a refractive index of 2.7 in a matrix combination of binders, auxiliary pigments and filler materials of refractive indices of approximately 1.5 to be in the range of 0.18-0.30 μm for 5 maximum light scattering per unit volume. With the advent of several advanced technologies, it is now possible to manufacture the TiO_2 particles precisely in the aforementioned particle size range. However, it is important to note that the mono-dispersed, single faceted and perfectly isometric spherical particles by virtue of their nature exhibit inferior light scattering properties. Furthermore, small TiO_2 particles 10 tend to agglomerate preferentially due to relatively large Hamaker constant (6×10^{-20} J) and hence van der Waals attractive force between TiO_2 particles. The increased crowding of TiO_2 particles due to agglomeration is detrimental to opacity owing to the fact that the several individual light scattering sources combine to act as one *via* 15 agglomeration.

15 Therefore, the major considerations to design a composite pigment purely from the physical optics point of view are: a) to select a pigment material with a large refractive index value such as TiO_2 with the objective of achieving a maximum difference between the matrix (carrier pigment or base sheet paper) or medium (water) in which the pigment is fixated or suspended; b) to tailor-make the particle size of 20 TiO_2 to yield optimum light scattering performance; and c) to space the pigment particles of high refractive index effectively to avoid optical interference and, hence, to maximize the number of light scattering sources.

In addition to physical optics, the design of composite pigments involve the selection of a carrier pigment that provides a congenial atmosphere for the strong 25 fixation of TiO_2 particles without compromising the desired optical properties as discussed above. Once again, the Fresnel law provides a rough guideline for the choice of carrier pigment in terms of refractive index. Kaolins are one of the best choices that possesses optimum optical and surface characteristics for a carrier pigment. The plate like nature of the kaolin is especially advantageous to obtain the 30 desired spacing of TiO_2 particles. Often, kaolins, which have been thermally bulked at 1000-1100° C (calcined clays), are used as a carrier pigment owing to their enhanced optical properties. Once the choice of appropriate premium pigments and

pigment extenders are made, the next important step is to devise ways to aggregate the pigments.

Prior Art

A critical review of the prior art of aggregating a single pigment or more than one pigment particulates to form a composite pigment suggests several routes. First, homogenizing the surface with an inorganic dispersant and homocoagulating with a multivalent metal ion. In this category the prior art dates half a century back when Alessandroni in U. S. Pat. No. 2,176,876 in 1938 prepared a composite pigment consisting of high refractive index pigments, such as TiO_2 , with materials of low and medium refractive indices (1.5-2.0) such as lead carbonate and barium sulfate by coflocculating them using sodium silicate and aluminum chloride. Later, Wildt in U. S. Patent No. 3,726,700 illustrated the method of making composite pigments consisting of TiO_2 particles (3-50%, by weight) and mineral extenders using an *in situ* formed continuous alumino-silicate gel as intrinsic cements. Kurrale in U. S. Patent No. 4,117,191 used metal silicate, specifically, a mixture of sodium silicate and $CaCl_2$. The purpose of precipitating Ca-silicate on clay or TiO_2 minerals is to space the pigment matter to enhance their optical properties.

Kaliski in his various U. S. patents No. 5,116,418, No. 5,279,663; No. 5,312,484; No. 5,346,548; No. 5,378,399 described a modified version of gel-setting cements for the manufacturing of structural aggregate pigments. In U. S. Patent No. 5,116,418, Kaliski described an *in situ* formation of a "functional hydrosol" by reacting sodium silicate and sodium aluminate and subsequently synthesizing "microgel" by reacting the functional hydrosol with calcium ions. Kaliski suggested that this *in situ* formed "microgel" - complex calcium aluminosilicate is capable of flocculating the particulate matter instantaneously, indiscriminately, and rapidly. In U. S. patent No. 5,116,418, and No. 5,279,663, Kaliski illustrated a process that structurally aggregate different hydrous clay particulates using "microgel" - an intrinsically built-in complex with functional properties. Later in U. S. Patent No. 5,312,484, No. 5,346,546, Kaliski described the use of "microgel" in agglutinating TiO_2 with secondary pigmentary particles such as calcined clay and hydrous clay in such a manner to provide optical properties equivalent to pure TiO_2 pigments.

In the second category, the pigment particulates are directly coagulated using a bi-, tri-, or tetra-valent metal ions. Jones in WO 87/00544 used silicon tetrachloride.

Later, Raythatha in U. S. Patent No. 4,826,536 disclosed a process of aggregating fine particulate kaolin with a metal chloride having the general formula MCl_x , where M is Si, Al, or Ti; and x is 3 or 4 depending on the valence of M, (e.g. silicon tetrachloride), under controlled moisture environment. According to Raythatha in U. S. Patent No. 4,326,536, the high level of moisture in the reaction introduced through the feed causes hydrolysis of metal chlorides which resulted in an inefficient aggregation. Raythatha in U. S. Patent No. 4,818,294 also disclosed another method of producing aggregated kaolin using organo-silicon compounds having a general formula Si (OR) where R is an alkyl group containing up to six carbon atoms. Recently, Dickey et al. in U. S Patent 5,458,680 used a similar method to produce a composite pigment of ground calcium carbonate and kaolin.

On the other hand, Pratt et al. in U.S. Patent 4,738,726 and Nemeh in U. S. Patent No. 5,152,835 used an organic polymer, namely dimethyl diallyl quaternary ammonium chloride polymer (commercially available under trademark designation Polymer 261 LV from Calgon Corporation), to flocculate kaolin and a slurry containing TiO_2 and calcined clay, respectively.

In the third category, *in situ* polymerization or condensation of one or more organic compounds mixed with the pigment particulates were used. Fadner in U. S. Pat. No. 3,453,131 used aliphatic dicarboxylic acid such as adipic acid to couple functional colloids such as carbon black to non swelling carrier clay particles. The effectiveness of complexation was monitored by the turbidity of the supernatant to examine for any distinct coloration or particle phases. Simone in U. S Patent No. 3,912,532 describes a method to encapsulate clay particles using urea-formaldehyde condensation polymer and Economou in U. S. Patent No. 4,346,178 used the same basic concept to produce improved light scattering properties although the structured pigments produced by Economou used much less urea-formaldehyde to produce an “open structure” with microvoids of desirable size in the product.

Bundy et al. in U. S Patent Nos 4,075,941 and 4,076,548 used diamine and polyamines in mixture with citric acid to flocculate clay having particle size of 94% below 2 mm with a small quantity of mica (0.1-0.4%) as the feed material to produce high bulking clay pigments. Further, Bundy et al. described in U. S. Patent 4,078,030 that the calcination of the product obtained in the aforementioned patents enable additional bulking of the pigments.

All the aforesaid patents focus on achieving superior optical properties using composite pigment technologies. However, aside from optical properties, it is important to enunciate that successful commercialization of the pigments also depend on the provision of products that have acceptable fluidity when dispersed in water at practical pigment solids levels and these slurries must resist settling under static condition. For example, the pigment should be capable of being formed into a high solids slurry e.g., one containing at least 55%, preferably at least 57% pigment solids and most preferably at least 59% pigment solids. Such slurry should be sufficiently fluid to have a Brookfield viscosity (20 rpm) below 800 cps, preferably below 500 cps at 20 rpm. Unfortunately, the existing processes for making composite pigments have not been able to achieve the high solid slurries that are desirable. In addition, some of the existing composite pigments are difficult to make on a commercial basis.

SUMMARY OF THE INVENTION

It is an object of this invention to develop an composite aggregate with superior optical properties and which is capable of being formed into a high solids slurry.

It is a further object of this invention to develop a superior composite aggregate pigment that uses a large percentage of the secondary pigments with a small percentage of TiO_2 to produce a pigment with optical properties comparable to TiO_2 pigments.

It is a specific object of this invention to develop a process for producing an aggregate composite pigment with TiO_2 and calcined clay which has superior optical properties.

These objects have been achieved by this invention by developing a process for aggregating a small proportion of TiO_2 with calcined clay so as to produce a pigment with superior optical and fluidity properties.

This composite aggregate pigment is prepared by blending a slurry of titanium dioxide with a slurry of calcined clay in a slurry using polyaluminum chloride (PAC). From 2 to 60.0 parts by weight of titanium dioxide is mixed with from 40 to 98 parts by weight of calcined clay in a slurry. From 0.01 to 20 parts by weight of polyaluminum chloride (PAC) is used to aggregate the pigment. This process is basically conducted by agitating in a slurry titanium dioxide and calcined clay and

adding PAC liquid to it. A dispersant, such as an anionic polyelectrolyte may be added to preserve the necessary fluidity.

In place of using titanium dioxide, a mixture of titanium dioxide and other pigment materials with a high refractive index (i.e., above 2) may be used in a ratio to 5 titanium dioxide from 10:1 to 1:10. Examples of other pigment materials with a high refractive index are zirconium oxide and zinc sulfide.

A pigment extender can be substituted for from 0.1 to 90.0% by weight of the calcined clay in the pigment, if desired. The following pigment extenders, and mixtures thereof, may be used:

- 10 a) commercially available hydrous kaolin;
- b) silica, preferably obtained by ashing rice husk or hull at 400-800°C.
- c) ground calcium carbonate of particle size essentially 100% by weight, finer than 5 μm e.s.d.
- d) precipitated calcium carbonate of a particle size which is essentially 15 100% by weight finer than 5 μm e.s.d.
- e) needle-shaped wollastonite particles, which may either be synthetic or natural, having an aspect ratio of from 5:1 to 2:1 of the length of the particle to its diameter.

One of the following auxiliary pigments can be substituted for from 0.1 to 5 20 parts by weight of the calcined clay in the mixture:

- a) carbon, preferably obtained by adding rice husk or hull at 400-800°C;
- b) synthetic aluminosilicate spheres with a hollow core of from approximately 1-25 μm outer diameter and 0.01 to 10 μm core diameter.

It has been found that the auxiliary pigment described in b) improves the flow 25 characteristics of the slurry when it has a high viscosity.

The term polyaluminum chloride (PAC) is defined to include aluminum chlorohydrate and mixtures of polyaluminum chloride and aluminum chlorohydrate. The PAC should have basicity of between 10 and 90% and preferably between 40% and 90%. In place of utilizing polyaluminum chloride, a mixture of polyaluminum 30 chloride with aluminum chlorohydrate can be substituted for the polyaluminum chloride in a 10:1 to 1:10 ratio. If desired, various bivalent and multivalent inorganic salts can be substituted in this process.

The pigment product of this invention is a structural aggregate of titanium dioxide, and calcined clay, using PAC. This composition is useful as a pigment for paper, paint, and plastic and other coating applications. The composition of this invention is basically a substitute for titanium dioxide pigments in that it possesses 5 comparable optical and fluidity characteristics.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The composite pigment of this invention can be used for coating applications on paper and plastic and for the preparation of paint. This composite pigment has high hiding and light scattering properties.

10 This composite aggregate pigment is prepared by mixing in a slurry from 2 to 60 parts by weight of titanium dioxide with from 40-98 parts by weight of calcined clay and from 0.1 to 20 parts by weight of polyaluminum chloride (PAC). Preferably, the TiO_2 is present in an amount from 20 parts to 50 parts by weight and the calcined clay is present in an amount of 50 parts to 80 parts by weight and PAC in an amount 15 from 0.1 to 10 parts by weight. It may be necessary to add a dispersant to the slurry in order to preserve the necessary fluidity and low viscosity necessary to produce the pigment.

20 The preferred particulate TiO_2 (rutile, anatase and brookite) materials used in preparing the composite pigment under discussion can be of the following types or blends thereof in any proportions and combinations:

- a) TiO_2 pigments sold commercially as rutile and anatase products, having essentially 100%, by weight, of particle size finer than 2 μm ; 98-99% finer than 1.5 μm ; 97.5-98.0% finer than 1.0 μm ; 30-35% finer than 0.3 μm in equivalent spherical diameter (e.s.d.).
- 25 b) precipitated TiO_2 particles that are commercially available.

In place of using titanium dioxide, a mixture of titanium dioxide with other pigment materials having a high refractive index (i.e., above 2), such as zirconium oxide and zinc sulfide, may be used in a 10:1 to 1:10 ratio.

30 The calcined clays are basically prepared by heating kaolin in the range of 1000 to 1100°C. It is preferred that the calcined clays have a particle size finer than 3 μm e.s.d. with approximately 90% of the calcined clays having a particle size finer than 2 μm e.s.d.. It is preferred that the average equivalent spherical diameter be between 0.4-0.8 μm .

From 0.1 to 90% by weight of one of the following pigment extenders may be substituted for a portion of the calcined clay in the mixture:

- a) commercially available hydrous kaolin.
- b) silica, preferably obtained by ashing rice husk or hull at 400-800°C.
- 5 c) ground calcium carbonate of a particle size which is essentially 100% by weight finer than 5 μm e.s.d.
- d) precipitated calcium carbonate of a particle size which is essentially 100% by weight finer than 5 μm e.s.d.
- 10 e) needle-shaped wollastonite particles, which may either be synthetic or natural, having an aspect ratio of from 5:1 to 2:1 of the length of the particle to its diameter.

The hydrous kaolin has a very fine particle size where its largest particles are about 80% by weight, finer than 2 μm e.s.d., 65% by weight, finer than 1 μm e.s.d., 40% by weight finer than 0.4 μm e.s.d. These pigment extenders can be used either alone or 15 in a mixture thereof. These pigment extenders may be used to achieve the desired optical or physical properties of the pigment and also to reduce costs.

One of the following auxiliary pigments can be substituted for from 0.1 to 5% by weight of the calcined clay in the mixture:

- a) carbon, preferably obtained by adding rice husk or hull at 400-800°C;
- 20 b) synthetic aluminosilicate spheres with a hollow core of from approximately 1-25 μm outer diameter and 0.01 to 10 μm core diameter.

It has been found that the auxiliary pigments described in b) improves the flow properties of the slurry when it has a high viscosity.

The slurry of TiO_2 and calcined clay is chemically structured by adding a 25 polyaluminum chloride to the slurry during mixing. The term PAC also includes aluminum chlorohydrate and mixtures of polyaluminum chloride with aluminum chlohydrate in a 10:1 to 1:10 ratio. The weight of the PAC is determined after conducting a microwave drying process (@20% power of a CEM microwave oven). Model AVC-80 was used in the preparation of these pigments.

30 The PAC should have a degree of neutralization, namely the molar ratio, or the basicity as defined by following relationship:

$$\% \text{Basicity} = \frac{[\text{OH}]}{3 * [\text{Al}]} * 100, \quad [2]$$

between 10% to 90%.

A slurry obtained by mixing at least one form of particulate titanium dioxide and calcined clay can render a loose blend of solids of at least 1-64%, by weight, and preferably in the 55-62% range, and most preferably, in the 58-62% range. The pH of 5 the above said loose blend can be obtained naturally in the range of 4-12, or can be adjusted using a standard inorganic acid such as HCl or H₂SO₄ and alkali such as NaOH or NaHCO₃, Na₂CO₃. It is, however, preferred to maintain the pH in the range of 7-11, and most preferably in the range of 8.5-10.5.

The preferred process for synthesizing the composite pigments of the present 10 invention include the addition of PAC in an amount of 0.01 to 20 parts, by weight, as determined by the microwave drying process with the PAC having at least one degree of neutralization, or a basicity (as defined by the relationship in Eq. [2]) between 10% to 90%. Preferably, the basicity is between 25% and 90%. From 0.01 parts to 20 parts, by weight, can be used of aluminum chlorohydrate or a mixture of 15 polyaluminum chloride with aluminum chlorohydrate in a ratio of 10:1 to 1:10 ratio.

Optionally, 0.01 to 4 parts, by weight of bi or polyvalent metal cations selected from periodic table group IIa, IIb, IIIa, VIa, and VIb can be added to enhance the aggregation kinetics.

The exact mechanism of rapid aggregation of the negatively charged TiO₂ and 20 the calcined clay is quite complex. However, because of the fact that PAC contains multi-nuclear polyvalent cationic species with the most dominating polymeric species with a chemical formula being Al₁₃O₄(OH)₂₄⁷⁺ (Steelhammer et al. PIMA February 1992), the instantaneous coagulation may be attributed to the charge neutralization of 25 surface negative charges of TiO₂ and calcined clay in the presence PAC. Nonetheless, it is surprising that the aggregation of the pigments using PAC produces the necessary optical properties combined with the desired handling properties.

Thus, the addition of PAC thickens the colloidal suspension as a result of 30 strong coagulation, e.g., Brookfield viscosity exceeds 1000 cps at 20 rpm. To convert the thick suspension into a fluid of rather manageable form, additional dispersant, essentially anionic polyelectrolytes, can be added. The amount of dispersant should be such that a fluid system having solid content of at least 55%, by weight, with Brookfield viscosity under 1000 cps at 20 rpm in the pH range of 7-10 is obtained as the final product.

In a presently preferred embodiment of the invention, a slurry of loose blend containing 35-45 parts (solids) TiO_2 and 55-65 parts (solids) calcined clay was prepared and blended at 200 rpm. The pH of the loose blend was adjusted in the range of 7.0 to 11.0, preferably between 8.5 to 10.5 with sodium hydroxide and 5 conditioned for about ten minutes at 750-800 rpm. To the resultant mixture, the required amount, typically 1-1.2 parts, by weight of the as received polyaluminum chloride liquid was added slowly. During addition, the slurry begins to form a viscous fluid which on continued addition becomes even thicker. At this point a small amount of dispersant will improve the shear thinning property of the slurry. However, 10 as a rule of thumb, the thicker the slurry gets before a dispersant is added the better it is for the final product in terms of optical properties. The addition of dispersant was continued to get the desired Brookfield viscosity of 500-700 cps. If the dispersant is added before the PAC is added to the slurry, poor optical properties are normally obtained. It is thought that the addition of the PAC before the dispersant is added 15 results in the neutralization of the surface negative charge on the calcined clay and TiO_2 . This facilitates the attractive forces between the TiO_2 and the calcined clay producing rapid coagulation.

Typical properties of the pigments prepared by the present invention have the following properties:

COMPOSITE PIGMENT PROPERTIES

<u>Constituents</u>	
Wt. Ratio of TiO ₂ /calcined clay	5/95 to 50/50
<u>Optical characteristics</u>	
G. E. Brightness	94 to 97
Scattering Coefficient @ 4g/m ²	0.44 to 0.51 @ 457 μm
Mylar Opacity @ 7lb/3300 ft ²	86.5 to 88.2
<u>Particle size</u>	
% Finer than 2mm	95%
Median diameter	0.40 to 0.45 μm
<u>Slurry properties</u>	
% Solids	59 to 61
+325 mesh residue, wt %	less than 0.3%, by wt
<u>Viscosity Specifications</u>	
Brookfield Viscosity, cps @20 rpm	400-700 @ 59-61% solids by weight
after one week	600-800 @ 59-61% solids by weight
after two weeks	600-800 @ 59-61% solids by weight

The pigment slurry, thus made by a batch or continuous process, exhibits sufficient shear stability to withstand production and handling conditions using conventional 5 commercial processing equipment and also is adequately stable for use in high speed coaters used by paper industry. Optionally, the composite pigment particles can be removed by conventional drying processes, preferably by flash or spray drying technique.

The particle size analyses reported in this invention are estimated by the 10 Sedigraph 5100 particle size analyzer as equivalent spherical diameters (e.s.d.) on a weight percentage basis. In the example, test results were obtained essentially according to the following TAPPI (Technical Association of the Pulp and Paper Industry) procedures:

15 75° gloss-TAPPI Standard using T480A om-85.

B&L opacity-TAPPI Standard T425 om-86

G.E. brightness-TAPPI Standard T452 om-87

Light scattering studies were determined on the pigments in some instances using black glass as the model substrates (Kaliski, A., in Journal of Technical

Association of the Pulp and Paper Industry (TAPPI), Vol. 53, No. 11, November 1970, pages 2077-2084 ("Performance of Some Clays in Starch Containing Paper-Coating Films; Part I. Black Glass Plates as Model Substrates"). This was done by coating a pigment slurry containing 48% solids, by weight, with 2% latex suspensions 5 onto a black glass plate at a coat weight of 2.0-6.0 g/m² (expressed as dry pigment). The reflectance of the coatings after air drying is measured at wavelengths 457 nm and 577 nm by means of an Elrepho reflectometer. The reflectance values are converted by the use of Kubelka-Munk equations to light scattering coefficients (m²/g). The light scattering coefficients give an indication of the opacifying potential 10 of the pigment, vis-à-vis the degree of bulking of the composite pigment. The higher the values of light scattering coefficients, the rarer is the light passing through the pigment coating or the larger is the reflected and back scattered light. Reflectance is measured at two different wavelengths. The wavelengths 457 nm and 577 nm correspond to the wavelength used in the TAPPI brightness and opacity 15 measurements, respectively. The ratio of these light scattering coefficients ($\rho = SC_{577}/SC_{457}$) is directly related to coarse nature of the coating structure below certain binder-volume fraction which corresponds to 5-8%, by weight. At a constant binder-volume fraction the increase in " ρ " is an indication of improved light scattering properties of the pigments.

20 The opacity measurements were made by coating the pigment @ 50 % solids on a transparent polyester film, used for overhead projection, (Labelon Co., Canandaigua, NY) of thickness specified as 4 mil at 4-5 different coat weights using various wire wound coating rods. The coatings were dried overnight in a controlled environment complying to TAPPI standards (50% humidity; 23° C ambient 25 temperature). Using a 3"X7" template, the middle portion of the coatings was isolated and several opacity measurements were made and averaged using a BNL-2 Opacimeter according to TAPPI Standard T425 om-86. The resultant opacity vs coat weight plot was interpolated to 7.0 lb/3300ft² coat weight for comparison and reported as acetate opacity in the tables.

30 In preparing coating colors for light weight coating, a standard formulation has been used with conventional additives or mixtures with the aggregate composite pigment slurry of the present invention. Typically coating colors for light weight coatings are obtained by mixing premium pigments, primary coating pigments, binder

materials such as casein, soybean proteins, starches (dextrans, oxidized starches) rubber lattices, styrene butadiene copolymer latex and synthetic polymeric resin emulsions such as derived from acrylic and vinylacetates.

5 The coating color compositions prepared in accordance with the present invention can be applied to base sheets in a conventional manner. This is one of the salient features of the pigments of this invention.

10 The pigments of this invention can be used as substitutes for TiO_2 pigments. The pigments of this invention have optical and physical properties comparable to TiO_2 pigments. These pigments may be used in paints and coatings requiring good hiding and light scattering characteristics.

Having now fully described this invention, it will be apparent to one of ordinary skill in the art that many changes and modifications can be made thereto without departing from the spirit or scope of this invention as set forth herein.

15 The coating colors containing the composite pigments prepared in the following examples were tested by applying using a CLC 6000 coating machine on a base stock of weight 27 lbs/3300ft² (Weyerhaeuser Paper Co) at the following set-up:

Speed FPM	3500
Blade	0.015"
Blade Extension	0.4"
20 Backing Blade	0.125"
Blade angle	50°
Shutter height	2.0"
Predry Time (Sec)/Power(HP)	25/80
Postdry Time(sec)/Power(HP)	30/100

25 The coated sheets were calendered to a gloss value of 52-55 in 2 nips @ 1500 psi and 135-155° F.

EXAMPLE 1

In the following examples, the pigments of this invention were prepared from a master batch of blended slurry containing slurries of 3383.82 g (1800 g dry) 30 calcined clay (Norcal[®] obtained from Nord Kaolin Co. Jeffersonville, GA) and 1572.8 g (1200 g dry) TiO_2 pigments from SCM Co.

EXAMPLE 1(a)

826.0 g. (500.0 g dry) of blended slurry containing 40% TiO₂ and 60% calcined clay, by weight, was agitated in a drill press at 200 rpm for 10 min. The pH of the slurry was measured and then the agitation was increased to 750 rpm. To the 5 resultant slurry, 5.975 g (23.9 lb/Ton) as received PAC liquid from Geo Chemicals, Syracuse, NY. of Sp. Gr.= 1.195 and % solids=33% was added slowly. While the addition continued, the viscosity of the slurry begins to increase, forming a viscous mass, and further thickens with prolonged addition. At this point, it is necessary to add a small amount of dispersant Rohm & Haas 9400 (R&H 9400 obtained from 10 Rohm & Haas Co. North Olmsted, OH) to increase the fluidity or lower the viscosity of the slurry. Once the slurry becomes fluid, the addition of PAC was continued until the slurry becomes viscous once again. As mentioned before, the addition of small amount of dispersant was made once again to improve the fluidity of the slurry. This process was repeated until the entire amount of PAC liquid was added. After mixing 15 the slurry for ten minutes, the Brookfield viscosity measurements were made and adjusted to 500-700 cps @ 20 rpm by adding dispersant (R & H 9400). The percent solids and pH were measured and the slurry was stored in a plastic bottle.

EXAMPLE 1(b)

826.0 g. (500.0 g dry) of blended slurry containing 40% TiO₂ and 60% calcined clay, by weight, was worked in a drill press at 750 rpm for 10 min. To the 20 resultant slurry, 5.975 g (23.9 lb/Ton, calculated on a dry basis) as received PAC liquid of Sp. Gr.= 1.195 and % solids=33% was added slowly. When the addition continues, the slurry becomes a viscous mass and thickens with further addition. At this point, a small amount of sodium silicate was added from a 5% sodium silicate 25 solution to increase the dispersion of the slurry. Once the slurry becomes fluid, the addition of PAC was continued until the slurry becomes viscous once again. Once again, the addition of sodium silicate commences when the slurry becomes viscous. The process of coagulating with PAC and dispersing with sodium silicate was 30 repeated until the entire amount of PAC liquid was consumed. The amount of sodium silicate added was 5 lb/Ton. After mixing the slurry for ten minutes, the Brookfield viscosity measurements were made and adjusted to 500-700 cps @ 20 rpm by adding a dispersant (R & H 9400). The percent solid content and pH were measured and the slurry was stored in a plastic bottle.

Table 1: Effect of Sodium Silicate

#	PIGMENT	PAC* (lb/ Ton)	Sod. Sil. lb/Ton	pH of L-B	SC ₄₅₇ (@4g/m ²)	Final pH	Final Solids (%)
1	Loose Blend (L-B)	-	-	6.7	0.38	7.4	60.53
2	Example 1a	23.9	-	6.7	0.4674	5.7	59.31
3	Example 1b	23.9	5	6.7	0.4409	5.5	58.61

Notes: * Basicity of the PAC is 45-55 %

5 SC₄₅₇: Scattering Coefficient at 457 nm

Shown in Table 1 are the scattering coefficients of the pigment layer coated on a black glass obtained at 457 nm in the presence of PAC and sodium silicate. Usually, the increase in the black glass scattering coefficients is an indication of enhanced light scattering property of the pigments and also a good tool to identify if 10 there is any bulking of the pigments. It is clear from Table 1 that the light scattering coefficients were lower for the loose blend compared to Ex. 1a and 1b, showing that PAC enhances the light scattering properties of the pigments.

EXAMPLE 2

In the following examples, the pigments of this invention were prepared from 15 a master batch of blended slurry containing slurries of 3383.82 g (1800 g dry) calcined clay (Norcal[®]) and 1558.8 g (1200 g dry) TiO₂ pigments from TiOxide Co.

EXAMPLES 2(a) & 2(b)

828.36 g. (500.0 g dry) of blended slurry containing 40% TiO₂ and 60% calcined clay, by weight, was agitated in a drill press at 750 rpm for 10 min. The pH 20 of the slurry was adjusted to the desired value (see Table 2) using 5% solution of sodium hydroxide and agitated at 750 rpm for 10 min. To the resultant slurry, 5.975 g (23.9 lb/Ton) as received PAC liquid of Sp. Gr.= 1.195 and % solids=33% was added slowly. While the addition continued, the viscosity of the slurry begins to increase, forming a viscous mass, and further thickens with further addition. At this point, it is 25 necessary to add a small amount of dispersant (R & H 9400) to increase the fluidity or lower the viscosity of the slurry. Once the slurry becomes fluid, the addition of

PAC was continued until the slurry gets viscous once again. As mentioned before, the addition of small amount of dispersant was made once again to improve the fluidity of the slurry. This process was repeated until the entire amount of PAC liquid was added. After mixing the slurry for ten minutes, the Brookfield viscosity measurements were made and adjusted to 500-700 cps @ 20 rpm by adding a dispersant (R & H 9400). The percent solid content and pH were measured and the slurry was stored in a plastic bottle.

Table 2: Effect of pH

#	PIGMENT	PAC (lb/ Ton)	pH of L-B	Acetate Opacity (@7lb/330 0 ft ²)	SC ₄₅₇ (@4g/m ²)	Final Solids (%)	Final pH
1	2(a)	23.9	6.7	86.63	0.4186	59.36	5.6
2	2(b)	23.9	8.45	87.49	0.4712	59.64	6.45
3	Loose blend (L-B)	-	6.7	81-82	0.37- 0.38	60.36	6.7

10 Note: Basicity of the PAC is 45-55 %

SC₄₅₇: Scattering Coefficient at 457 nm

It is surprising to note that the results indicate that adjusting the pH of the loose blend to an alkaline pH before adding PAC is beneficial to the light scattering properties and opacity of the pigment.

15

EXAMPLE 3

In the following examples, the pigments of this invention were prepared from a master batch of blended slurry containing slurries of 5606.43 g (3000 g dry) Norcal® (calcined clay) and 2640.61 g (2000 g dry) TiO₂ pigments from TiOxide Co.

EXAMPLE 3(a)

20

1643.66 g. (1000.0 g dry) of blended containing 40% TiO₂ and 60% calcined clay, by weight, was agitated in a drill press at 750 rpm for 10 min. The pH of the slurry was adjusted to 8.6 using sodium hydroxide while agitating at 750 rpm for 10 min. To the resultant slurry, 11.9 g (23.9 lb/Ton) of as received PAC liquid from Geo Chemicals, Syracuse, NY. of Sp. Gr.= 1.195 and % solids=33% was added slowly.

25

While the addition continued, the viscosity of the slurry begins to increase, forming a viscous mass, and further thickens with prolonged addition. At this point, it is

necessary to add a small amount of dispersant (R & H 9400) to increase the fluidity or lower the viscosity of the slurry. Once the slurry becomes fluid, the addition of PAC was continued until the slurry gets viscous once again. As mentioned before, the addition of small amount of dispersant was made once again to improve the fluidity of the slurry. This process was repeated until the entire amount of PAC liquid was added. After mixing the slurry for ten minutes, the Brookfield viscosity measurements were made and adjusted to 500-700 cps @ 20 rpm by adding a dispersant (R & H 9400). The total amount of dispersant (R & H 9400) added during the process is 6.2 g (12.4 lb/Ton). The percent solid content and pH were measured and slurry was stored in a plastic bottle.

EXAMPLE 3(b)

1643.66 g. (1000.0 g dry) of blended slurry containing 40% TiO₂ and 60% calcined clay, by weight, was agitated in a drill press at 750 rpm for 10 min. The pH of the slurry was adjusted to 8.6 using sodium hydroxide while agitating at 750 rpm for 10 min. To the resultant slurry, 6.4 g (12.4 lb/Ton) of R & H 9400 polyelctrolyte dispersant was added. This is followed by the addition of 11.9 g (23.9 lb/Ton) of as received PAC liquid of Sp. Gr.= 1.195 and % solids=33% in a slow manner. While the addition continued, the viscosity of the slurry begins to increase, forming a viscous mass, and further thickens with prolonged addition. However, it was not necessary to add any dispersant to adjust the Brookfield viscosity since the viscosity was obtained in the 500-700 cps range @ 20 rpm. The percent solid content and pH were measured and the slurry was stored in a plastic bottle.

Table 3: Sequence of PAC and Dispersant Addition

#	PIGMENT	PAC (lb/ Ton)	Dispersant R & H 9400 (lb/Ton)	pH of L-B	Acetate Opacity (@7lb/3300 ft ²)	SC ₄₅₇ (@4g/ m ²)	Final pH	Hercules Viscosity @18 dynes	Final Solids (%)
1	loose blend (L-B)	-	-	6.7	81-82	0.37- 0.38	-	-	60.84
2	Example 3(a)	23.9	12.4	8.6	88.13	0.4700	6.2	300 rpm	60.10
3	Example 3(b)*	23.9	12.4	8.6	-	0.4350	6.9	400 rpm	60.65

25 Notes: * dispersant was added before adding PAC. Basicity of the PAC is 45-55 %
SC₄₅₇: Scattering Coefficient at 457 nm

From example 3(a) and 3(b), it is very clear that the addition of dispersant as a precursor to complexation is certainly not advantageous to optical properties as indicated by the poor black glass scattering values. However, it is interesting to note comparable viscosity and other physical properties in Example 3(a) and 3(b). It 5 appears that the complexation between discrete charge sites of the particle surface is more favorable for bulking than when it occurs between the charges on the polymeric dispersants coated on the particles.

In summary, the studies conducted thus far indicate the importance of conditioning the loose blend at alkaline pH, the detrimental nature of sodium silicate, 10 and the deleterious effect caused by the inverting the sequence of addition of the PAC and the dispersant. With this background, an elaborate study was conducted to investigate the effect of pH and PAC dosage. This investigation was conducted with the aim of optimizing the operating variables namely pH and PAC dosage.

EXAMPLE 4

15 In the following examples, the pigments of this invention were prepared from a master batch of blended slurry containing slurries of 22317 g (12000 g dry) Norcal® (calcined clay) and 10526.7 g (8000 g dry) UDR-606 TiO₂ pigments from Kemira Co. A detailed study has been conducted on varying the pH from 8.5 to 10.5 and dosage of PAC from 17.9 lb/Ton to 29.9 lb/Ton.

20 **EXAMPLE 4(a)**

2489.6 g. (1500.0 g dry) of blended slurry containing 40% TiO₂ and 60% calcined clay, by weight, was agitated in a drill press at 750 rpm for 10 min. The natural pH of the loose slurry was 8.6. To the resultant slurry, 13.4 g (17.9 lb/Ton) of as received PAC liquid of Sp. Gr.= 1.195 and % solids=33% was added slowly. 25 While the addition continued, the viscosity of the slurry begins to increase, forming a viscous mass, and further thickens with prolonged addition. At this point, it is necessary to add a small amount of dispersant (R & H 9400) to increase the fluidity or lower the viscosity of the slurry. Once the slurry becomes fluid, the addition of PAC was continued until the slurry gets viscous once again. As mentioned before, the 30 addition of small amount of dispersant was made once again to improve the fluidity of the slurry. This process was repeated until the entire amount of PAC liquid was added. After mixing the slurry for ten minutes, the Brookfield viscosity measurements were made and adjusted to 500-700 cps @ 20 rpm by adding a

dispersant (R & H 9400). The percent solid content and pH were measured and the slurry was stored in a plastic bottle.

EXAMPLE 4(b)

2489.6 g. (1500.0 g dry) of blended slurry containing 40% TiO₂ and 60% calcined clay, by weight, was agitated in a drill press at 750 rpm for 10 min. The pH of the loose slurry was adjusted to 10.35 using sodium hydroxide. To the resultant slurry, 17.93 g (23.9 lb/Ton) of as received PAC liquid of Sp. Gr.= 1.195 and % solids=33% was added slowly. While the addition continued, the viscosity of the slurry begins to increase, forming a viscous mass, and further thickens with prolonged addition. At this point, it is necessary to add a small amount of dispersant (R & H 9400) to increase the fluidity or lower the viscosity of the slurry. Once the slurry becomes fluid, the addition of PAC was continued until the slurry becomes viscous once again. As mentioned before, the addition of small amount of dispersant was made once again to improve the fluidity of the slurry. This process was repeated until the entire amount of PAC liquid was added. After mixing the slurry for ten minutes, the Brookfield viscosity measurements were made and adjusted to 500-700 cps @ 20 rpm by adding a dispersant (R & H 9400). The percent solid content and pH were measured and the slurry was stored in a plastic bottle.

EXAMPLE 4(c)

2489.6 g. (1500.0 g dry) of blended slurry containing 40% TiO₂ and 60% calcined clay, by weight, was agitated in a drill press at 750 rpm for 10 min. The natural pH of the loose slurry was 8.6. To the resultant slurry, 22.4 g (29.9 lb/Ton) of as received PAC liquid of sp. Gr.= 1.195 and % solids=33% was added slowly. While the addition continued, the viscosity of the slurry begins to increase, forming a viscous mass, and further thickens with prolonged addition. At this point, it is necessary to add a small amount of dispersant (R & H 9400) to increase the fluidity or lower the viscosity of the slurry. Once the slurry becomes fluid, the addition of PAC was continued until the slurry gets viscous once again. As mentioned before, the addition of small amount of dispersant was made once again to improve the fluidity of the slurry. This process was repeated until the entire amount of PAC liquid was added. After mixing the slurry for ten minutes, the Brookfield viscosity measurements were made and adjusted to 500-700 cps @ 20 rpm by adding a

dispersant (R & H 9400). The percent solid content and pH were measured and the slurry was stored in a plastic bottle.

EXAMPLE 4(d)

2489.6 g. (1500.0 g dry) of blended slurry containing 40% TiO_2 and 60% calcined clay, by weight, was agitated in a drill press at 750 rpm for 10 min. The pH of the loose slurry was adjusted to 9.5 using sodium hydroxide. To the resultant slurry, 22.4 g (29.9 lb/Ton) of as received PAC liquid of sp. Gr.= 1.195 and % solids=33% was added slowly. While the addition continued, the viscosity of the slurry begins to increase, forming a viscous mass, and further thickens with prolonged addition. At this point, it is necessary to add a small amount of dispersant (R & H 9400) to increase the fluidity or lower the viscosity of the slurry. Once the slurry becomes fluid, the addition of PAC was continued until the slurry gets viscous once again. As mentioned before, the addition of small amount of dispersant was made once again to improve the fluidity of the slurry. This process was repeated until the entire amount of PAC liquid was added. After mixing the slurry for ten minutes, the Brookfield viscosity measurements were made and adjusted to 500-700 cps @ 20 rpm by adding a dispersant (R & H 9400). The percent solid content and pH were measured and the slurry was stored in a plastic bottle.

Table 4: Effect of pH and PAC Dosage

20

#	PIGMENT	PAC (lb/ Ton)	pH of L-B	Acetate Opacity (@7lb/3 300 Ft ²)	SC ₄₅₇ (@4g/m ²)	Final pH	Final Solids (%)
1	loose blend (L-B)	-	8.65	81-82	0.37-0.38	8.65	
2	Example 4(a)	17.9	8.65	87.41	0.4585	7.4	60.02
3	Example 4(b)	23.9	10.35	87.83	0.4668	8.0	59.30
4	Example 4(c)	29.9	8.65	87.56	0.4541	6.9	59.79
5	Example 4(d)	29.9	9.50	87.59	0.4593	7.4	59.57

Table 4 demonstrates that the addition of PAC increases the opacity and light capturing coefficients of pigments formed from TiO_2 and calcined clay by a significant amount. Increasing the amount of PAC added within the range set forth in

Table 4 does not seem to have a significant effect upon the light scattering coefficient or opacity. Likewise, increasing the basicity of the slurry does not seem to have a significant effect upon the opacity and light scattering coefficient of the pigment produced.

5

EXAMPLE 5

In the following examples, the pigments of this invention were prepared using aluminum chlorohydrate (ACH) of basicity (as defined in Eq. [2]) 83% at 23.9 lb/Ton.

1691.88 g. (1000.0 g dry) of blended slurry containing 40% TiO₂ and 60% calcined clay, by weight, was agitated in a drill press at 750 rpm for 10 min. The pH of the loose slurry was adjusted to 11.0 using 12.4g of 25% sodium hydroxide solution. To the resultant slurry, 18.0 g (23.9 lb/Ton) of as received aluminum chlorohydrate (PAC with basicity > 80%) liquid from Geo Chemicals, Syracuse, NY. of Sp. Gr.= 1.35 and % solids=50% was added slowly. While the addition continued, the viscosity of the slurry begins to increase, forming a viscous mass, and further thickens with prolonged addition. At this point, it is necessary to add a small amount of dispersant (R & H 9400) to increase the fluidity or lower the viscosity of the slurry. Once the slurry becomes fluid, the addition of aluminum chlorohydrate was continued until the slurry gets viscous once again. As mentioned before, the addition of small amount of dispersant was made once again to improve the fluidity of the slurry. This process was repeated until the entire amount of PAC liquid was added. After mixing the slurry for ten minutes, the Brookfield viscosity measurements were made and adjusted to 500-700 cps @ 20 rpm by adding a dispersant (R & H 9400). The percent solid content and pH were measured and the slurry was stored in a plastic bottle.

Table 5: Effect of Basicity of PAC

25

#	PIGMENT	PAC (lb/ Ton)	Basicity of the Comp. Agent%	pH of L-B	Acetate Opacity (@7lb/33 00 Ft ²)	SC ₄₅₇ (@4g/m ²)	Final pH	Final Solids (%)
1	loose blend (L-B)	-		8.65	81-82	0.37-0.38	8.65	-
2	Example 5(a)	23.9	80-90	10.6	88.95	0.5484	8.0	60.07
3	Example 4(b)	23.9	45-55	10.35	87.83	0.4668	8.0	59.37

Table 5 demonstrates very surprising results on the increase of the opacity and light scattering coefficient of the composite aggregate pigments with the increase in the basicities of PAC.

EXAMPLE 6

5 Four different composite pigments (6(a)-(d)) were prepared according to the procedure described in the example 4(b) with varying basicities of the PAC. The pigments, thus made, were then subjected to Light Weight Coating (LWC) studies on a base stock of 27lb/3300 ft² (Weyerhaeuser Paper Co.) using a cylindrical laboratory coater (CLC 6000 by Sensor & Simulation products, Weyerhaeuser, Tacoma, WA.) to evaluate their optical performance on a coated sheet.

10 Controls were UDR 606 (Kemira Co.) and RPS (Dupont) at 100%, by weight. In all the colors, composite pigments were used in the amount of 5.5 parts by weight. The remaining 94.5 parts by weight consists of delaminated kaolin (Norcote DL) and hydrous kaolin (Norcote II) in 3:1 ratio. On the other hand, the control TiO₂ pigments 15 were used in 5 parts with remaining 95 parts being delaminated kaolin (Norcote DL, obtained from Nord Kaolin Co. Jeffersonville, GA) and hydrous kaolin (Norcote II, , obtained from Nord Kaolin Co. Jeffersonville, GA) in 3:1 ratio. The other ingredients that are added during the color preparation are:

- 20 a) 8 parts of PG 280, hydroxy ethylated starch from Penford Products,
- b) 8 parts of CP 620 NA, styrene butadiene latex from Dow chemicals Corp.,
- c) 1 part of Sunkote 450, Calcium stearate emulsion, Sequa chemicals Inc., Chester, SC.,
- d) 0.3 parts of Sunrez 700M,cyclic amide aldehyde condensation product-25 an Insolubilizer from Sequa Chemicals Inc., Chester, SC., and
- e) 0.1 parts of colloids 211, Sodium polyacrylate solution from Colloids Inc., Newark, NJ.

30 All the coating colors were made at 57.5±0.2% solids and coated at three different coat weights on a base stock of 27lbs/3300 ft² obtained from Weyerhaeuser Paper Co. The coated sheets were calendered at 150° F to a gloss of 51±2 using two nips@ 1500 psi.

The optical properties of the coated sheet were evaluated at three different coat weight and interpolated at 5.5 lb/3300 ft² and reported in Table 6.

Table 6: Cylindrical Laboratory Coater Results

#	PIGMENT	Basicity (%)	Coated sheet Opacity (@5.5lb s/3300 ft ²)	Bright-ness (%)	Gloss (%)
1	6(a)	>80	82.80	71.12	49.52
2	6(b)	45-55	82.91	71.13	49.71
3	6(c)	25-40	82.29	70.83	52.82
4	6(d)	0	82.52	70.96	51.22
5	UDR 606	NA	83.14	71.52	51.66
6	RPS	NA	83.49	71.39	50.99

As is clear from Table 6, these results are quite significant considering the fact
5 that the pigments examples 6(a) to (d) in this invention contain only 40% of TiO₂
(UDR 606 from Kemira Co.). Besides superior optical performance, the composite
pigments produced in this invention can be shipped at higher solids content up to 61%
and at least 59% without having any undesirable settling effect. This is one of the
salient features of these pigments compared to other similar composite pigments
10 available commercially.

What is claimed is:

1. A chemically aggregated kaolin based composite after removal from the slurry in which it was produced useful as a pigment comprising:

- 5 a) from 2 to 60 parts by weight of particulate titanium dioxide;
- b) from 40 to 98 parts by weight of calcined clay; and
- c) from 0.01% to 20 parts by weight of polyaluminum chloride (PAC)

with a degree of basicity as defined by the following relationship:

$$\% \text{Basicity} = \frac{[\text{OH}]}{3 * [\text{Al}]} * 100,$$

of between 10 and 90%.

10 2. The chemically aggregated kaolin based composite of Claim 1 in which the titanium dioxide is present in an amount from 20 parts to 50 parts by weight, and the calcined clay is present in an amount of 50 parts to 80 parts by weight aggregated with the polyaluminum chloride (PAC) which is present in an amount from 0.1 to 10 parts by weight.

15 3. The chemically aggregated kaolin based composite of Claim 1 in which the basicity of the polyaluminum chloride (PAC) is between 25% and 90%.

4. The chemically aggregated kaolin based composite of Claim 1 in which the titanium dioxide has a particle size of essentially 100% by weight finer than 2 μm with 98-99% finer than 1.5 μm , 97.5 to 98% finer than 1 μm and 30 to 35% 20 finer than 0.3 μm in equivalent spherical diameter.

5. The chemically aggregated kaolin based composite of Claim 1 in which a pigment material with a refractive index above 2 is substituted for a portion of the titanium dioxide in a ratio of from 10:1 to 1:10.

6. The chemically aggregated kaolin based composite of Claim 5 in 25 which the pigment material with a high refractive index is zirconium oxide.

7. The chemically aggregated kaolin based composite of Claim 5 in which the pigment material with a high refractive index is zinc sulfide.

8. The chemically aggregated kaolin based composite of Claim 1 in which from 0.1 to 90% by weight of the calcined clay is replaced by a pigment extender selected from the group consisting of

a) hydrous kaolin;
5 b) silica;
c) ground calcium carbonate of particle size essentially 100% by weight, finer than 5 μm e.s.d.

d) precipitated calcium carbonate of a particle size which is essentially 100% by weight finer than 5 μm e.s.d.

10 e) needle-shaped wollastonite particles, with an aspect ratio of from 5:1 to 2:1 of the length of the particle in relation to its diameter.

9. The chemically aggregated kaolin based composite of Claim 1 in which from 0.1 to 5% by weight (based on the weight of the calcined clay) of the calcined clay is replaced by an auxilliary pigment selected from the group consisting of:

a) carbon;
b) synthetic aluminosilicate spheres with a hollow core of from approximately 1-25 μm outer diameter and 0.01 to 10 μm core diameter.

10. The chemically aggregated kaolin based composite of Claim 1 in which the polyaluminum chloride (PAC) has a degree of basicity of between 10 and 90% and is a mixture of polyaluminum chloride and aluminum chlorohydrate.

11. A slurry containing a chemically aggregated kaolin based composite useful as a pigment, said slurry containing a blend of solids comprising:

a) from 2 to 60% by weight of solids of particulate titanium dioxide;
25 b) from 40 to 98% by weight of solids of calcined clay; and
c) from 0.01% to 20 parts by weight of solids of polyaluminum chloride (PAC) with a degree of basicity as defined by the following relationship:

$$\% \text{Basicity} = \frac{[\text{OH}]}{3 * [\text{Al}]} * 100,$$

of between 10 and 90%.

30 12. The slurry of Claim 11 in which the blend of solids is present in the slurry in a range from 55 to 62% by weight of the slurry.

13. The slurry of Claim 11 which contains a sufficient amount of dispersent to obtain a Brookfield viscosity of from 500 to 700 cps at 20 rpm.

14. The slurry of Claim 11 in which from 0.1 to 5% by weight of the calcined clay in the slurry is replaced by an auxiliary pigment selected from the group 5 consisting of:

a) carbon;
b) synthetic aluminosilicate spheres with a hollow core of from approximately 1-25 μm outer diameter and 0.01 to 10 μm core diameter.

15. The slurry of Claim 11 in which 0.1 to 90% by weight of the calcined 10 clay in the slurry is replaced by a pigment extender selected from the following group consisting of:

a) hydrous kaolin;
b) silica;
c) ground calcium carbonate of particle size essentially 100% by weight, 15 finer than 5 μm e.s.d.

d) precipitated calcium carbonate of a particle size which is essentially 100% by weight finer than 5 μm e.s.d.

e) needle-shaped wollastonite particles, which may either be synthetic or natural, having an aspect ratio of from 5:1 to 2:1 of the length of the particle to its 20 diameter.

16. A method for producing a chemically aggregated kaolin based composite useful as a pigment comprising preparing a slurry by mixing in water the following compositions in a percentage by weight of solids as follows:

a) from 2 to 60% by weight of solids of particulate titanium dioxide;
25 b) from 40 to 98% by weight of solids of calcined clay, and;
c) from 0.01% to 20% by weight of solids of polyaluminum chloride (PAC) with a degree of basicity as defined by the following relationship:

$$\% \text{Basicity} = \frac{[\text{OH}]}{3 * [\text{Al}]} * 100,$$

of between 10 and 90%.

17. The method of Claim 16 in which the titanium dioxide is present in an amount from 20 parts to 50 parts by weight, and the calcined clay is present in an amount of 50 parts to 80 parts by weight aggregated with the polyaluminum chloride (PAC) which is present in an amount from 0.1 to 10 parts by weight.

5 18. The method of Claim 16 in which the basicity of the polyaluminum chloride (PAC) is between 25% and 90%.

10 19. The method of Claim 16 in which the titanium dioxide has a particle size of essentially 100% by weight finer than 2 μm with 98-99% finer than 1.5 μm , 97.5 to 98% finer than 1 μm and 30 to 35% finer than 0.3 μm in equivalent spherical diameter.

20. The method of Claim 16 in which a dispersent is added to the slurry after the addition of at least a portion of the polyaluminum chloride (PAC) and the viscosity of the slurry increases to an undesirable level in order to obtain and maintain a Brookfield viscosity of the slurry in the range of from 500 to 700 cps at 20 rpm.

15 21. The method of Claim 16 in which a pigment material with a high refractive index is substituted for a portion of the titanium dioxide in a ratio of from 10:1 to 1:10.

20 22. The method of Claim 16 in which from 0.1 to 5% by weight (based on the weight of the calcined clay) of the calcined clay is replaced by an auxiliary pigment selected from the group consisting of:

a) carbon;
b) the synthetic aluminosilicate spheres with a hollow core of from approximately 1-25 μm outer diameter and 0.01 to 10 μm core diameter.

25 23. The method of Claim 16 in which from 0.1 to 90% by weight of the calcined clay in the slurry is replaced by a pigment extender selected from the group consisting of:

30 a) hydrous kaolin;
b) silica;
c) the ground calcium carbonate; and
d) the precipitated calcium carbonate.
e) needle-shaped wollastonite particles, which may either be synthetic or natural, having an aspect ratio of from 5:1 to 2:1 of the length of the particle to its diameter.

24. The method of Claim 16 in which a sufficient amount of a dispersent is added as the viscosity of the slurry reaches an undesirable level in order to obtain and maintain a Brookfield viscosity of from 500 to 700 cps at 20 rpm.

25. The method of Claim 16 in which the polyaluminum chloride (PAC) 5 has a degree of basicity between 10 and 90% and the PAC is a mixture of polyaluminum chloride and aluminum chlorohydrate from 10:1 to 1:10 ratio.

26. A continuous process for producing a chemically aggregated kaolin based composite useful as a pigment comprising mixing in water to form a slurry of the following compositions in a percentage by weight of solid range as follows:

10 a) from 2 to 60% by weight of particulate titanium dioxide;
b) from 40 to 98% by weight of calcined clay; and
c) from 0.01% to 20% by weight of polyaluminum chloride (PAC) with a degree of basicity as defined by the following relationship composite:

$$\% \text{Basicity} = \frac{[\text{OH}]}{3 * [\text{Al}]} * 100,$$

15 in which the polyaluminum chloride (PAC) is added to the slurry as needed to form the composite and a dispersant is added after the addition of at least a portion of the polyaluminum chloride to maintain the viscosity of the slurry between a Brookfield viscosity of 500 to 700 cps at 20 r.p.m. while maintaining the pH of the slurry in the range of from 7 to 11 pH and recovering the chemically aggregated kaolin based 20 composite from the slurry after the formation of the composite.

27. The continuous process of Claim 26 in which the titanium dioxide is present in an amount from 20 parts to 50 parts by weight, and the calcined clay is present in an amount of 50 parts to 80 parts by weight aggregated with the polyaluminum chloride (PAC) which is present in an amount from 0.1 to 10 parts by 25 weight.

28. The continuous method of Claim 26 in which the basicity of the polyaluminum chloride (PAC) is between 25% and 90%.

29. The continuous method of Claim 26 in which the titanium dioxide has a particle size of essentially 100% by weight finer than 2 μm with 98-99% finer than 1.5 μm , 97.5 to 98% finer than 1 μm and 30 to 35% finer than 0.3 μm in equivalent spherical diameter.

5 30. The continuous method of Claim 26 in which the pigment material with a high refractive index is substituted for a portion of the titanium dioxide in a ratio of from 10:1 to 1:10.

10 31. The continuous method of Claim 26 in which the polyaluminum chloride (PAC) is a mixture of polyaluminum chloride and aluminum chlorohydrate from 10:1 to 1:10 ratio.

32. The continuous method of Claim 26 in which from 0.1 to 5% by weight (based on the weight of the calcined clay) of the calcined clay is replaced by an auxiliary pigment selected from the group consisting of:

15 a) carbon;
b) the synthetic aluminosilicate spheres with a hollow core of from approximately 1-25 μm outer diameter and 0.01 to 10 μm core diameter.

33. The continuous method of Claim 26 in which from 0.1 to 90% by weight of the calcined clay in the slurry is replaced by a pigment extender selected from the group consisting of:

20 a) hydrous kaolin;
b) silica;
c) ground calcium carbonate of particle size essentially 100% by weight, finer than 5 μm e.s.d.
d) precipitated calcium carbonate of a particle size which is essentially 100% by weight finer than 5 μm e.s.d.
25 e) needle-shaped wollastonite particles, which may either be synthetic or natural, having an aspect ratio of from 5:1 to 2:1 of the length of the particle to its diameter.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US96/20606

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : C09C 1/36

US CL : 106/416, 442, 446, 485, 486

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 106/416, 442, 446, 485, 486

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,346,546 A (KALISKI) 13 September 1994, col. 12, lines 50-56	5-7, 21, 30
Y	STEELHAMMER et al. Polyaluminum Chloride Primer Revisited. PIMA. February 1992. pages 2-3.	1-4, 10-13, 16-20, 24-29, 31
Y	US 5,458,680 A (SHURLING JR. et al) 17 October 1995, col. 6, lines 5-10.	5-7, 21 30
Y	US 4,874,466 A (SAVINO) 17 October 1989, col. 3, lines 1-65.	1-4, 10-13, 16-20, 24- 29, 31
Y	US 5,152,835 A (NEMEH) 06 October 1992, col. 2, line 49- col. 20, line 52.	1-4, 10-13, 16-20, 24- 29, 31

Further documents are listed in the continuation of Box C.

See patent family annex.

•	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance		
"E"	earlier document published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"Z"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

12 MARCH 1997

Date of mailing of the international search report

08 MAY 1997

Name and mailing address of the ISA/US
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DERWENT-ACC-NO: 1997-363650

DERWENT-WEEK: 199802

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TITLE: Kaolin based pigment composite useful for paper or plastic coating contains titanium di:oxide, a calcined kaolin clay and poly:aluminium chloride, for enhanced optical property titanium di:oxide substitute

INVENTOR: RAVISHANKAR S A

PATENT-ASSIGNEE: NORD KAOLIN CO[NORDN]

PRIORITY-DATA: 1996US-582207 (January 2, 1996)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE
WO 9724406 A1	July 10, 1997	EN
AU 9715670 A	July 28, 1997	EN
US 5690728 A	November 25, 1997	EN

DESIGNATED-STATES: AL AM AT AU AZ BB BG BR BY CA CH CN CZ DE DK EE ES FI GB GE HU IL IS JP KE KG KP LV MD MG MK MN MW MX NO NZ PL PT RO RU SD SE SG SI SK TJ TM TR TT UA UG UZ VN EA

APPLICATION-DATA:

PUB-NO	APPL-DESCRIPTOR	APPL-NO	APPL-DATE
WO1997024406A1	N/A	1996WO-US20606	December 24, 1996
US 5690728A	N/A	1996US-582207	January 2, 1996
AU 9715670A	Based on	1997AU-015670	December 24, 1996

INT-CL-CURRENT:

TYPE	IPC DATE
CIPS	C09C1/00 20060101
CIPS	C09D7/12 20060101
CIPS	D21H19/38 20060101

ABSTRACTED-PUB-NO: WO 9724406 A1**BASIC-ABSTRACT:**

A chemically aggregated kaolin based composite after removal from the slurry in which it was produced useful as a pigment comprises (in parts by weight):

- (a) 2 - 60 particulate titanium dioxide;**
- (b) 40 - 98 calcined clay; and**
- (c) 0.01 - 20 polyaluminium chloride (PAC) with degree of basicity as defined by formula (I) of 10 - 90%.**

%Basicity=[OH]/3*[Al]*100 (I)

Also claimed are:

- (i) a slurry of a chemically aggregated kaolin composite;**
- (ii) a method for producing a chemically aggregated kaolin based composite; and**
- (iii) a continuous process for producing a chemically aggregated kaolin based composite.**

USE - The composite is a pigment with enhanced optical properties and can be formed into a high solids content slurry typically with a concentration of at least 59% and a viscosity of below 500 cps. Used in coatings for paper and plastics and in the manufacture of paints.

ADVANTAGE - The composite has optical properties comparable to titanium dioxide pigments and is a substitute for titanium dioxide.

**TITLE-TERMS: KAOLIN BASED PIGMENT COMPOSITE USEFUL PAPER
PLASTIC COATING CONTAIN TITANIUM DI OXIDE
CALCINE CLAY POLY ALUMINIUM CHLORIDE ENHANCE
OPTICAL PROPERTIES SUBSTITUTE**

DERWENT-CLASS: A60 F09 G01

CPI-CODES: A08-E02; A11-C04B2; A12-B01; F05-A06B; G01-A08; G01-A10; G02-A03D; G02-A05C;

ENHANCED-POLYMER-INDEXING: Polymer Index [1.1] 018 ; P0000;

**Polymer Index [1.2] 018 ; ND00;
K9676*R; K9483*R; Q9999 Q7158*R
Q7114;**

**Polymer Index [1.3] 018 ; D00 F80 O* 6A
Al 3A Si 4A R01949 129788; D00 F20 Ti
4B Tr O* 6A R01966 686; D00 D70 Al 3A
Cl 7A; D00 D70 H* Al 3A O* 6A Cl 7A;
A999 A759; N9999 N5709; S9999
S1456*R; A999 A102 A077; A999 A771;
S9999 S1058 S1014; B9999 B5209
B5185 B4740;**

**Polymer Index [1.4] 018 ; D00 H* Al 3A
Si 4A O* 6A Cl 7A Ti 4B Tr; A999 A759;
N9999 N5709; S9999 S1456*R; A999
A102 A077; A999 A771; S9999 S1058
S1014; B9999 B5209 B5185 B4740;**

**Polymer Index [1.5] 018 ; G3418 D00
F80 O* 6A Ca 2A Si 4A; D00 F20 Zr 4B
Tr O* 6A R01521 1328; D00 Zn 2B Tr S*
6A R01525 5119; D00 F20 O* 6A Si 4A
R01694 107016; D00 F44 C* 4A O* 6A
Ca 2A R01278 89827; D00 D09 C* 4A
R01669 2211; A999 A102 A077; A999
A771;**

SECONDARY-ACC-NO:

CPI Secondary Accession Numbers: 1997-116588